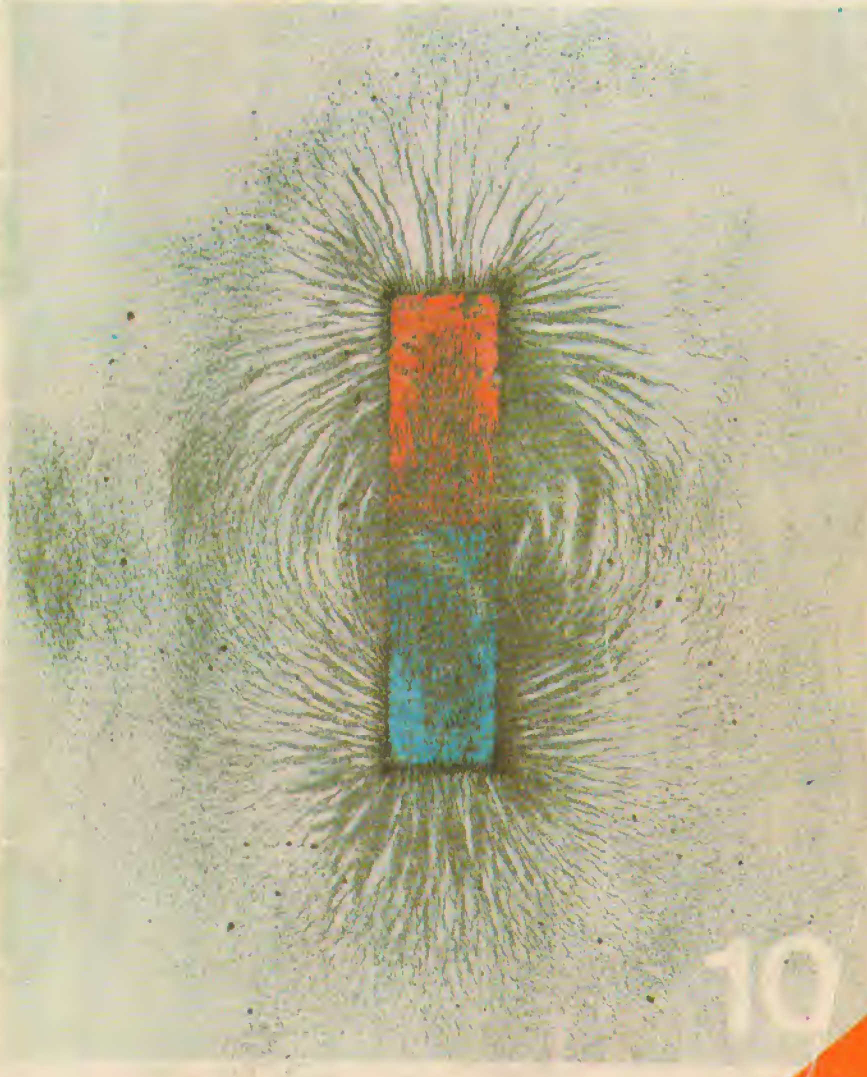
BASIC SCIENCE SERIES



MAGNETISM

REVISED EDITION

CONTENTS

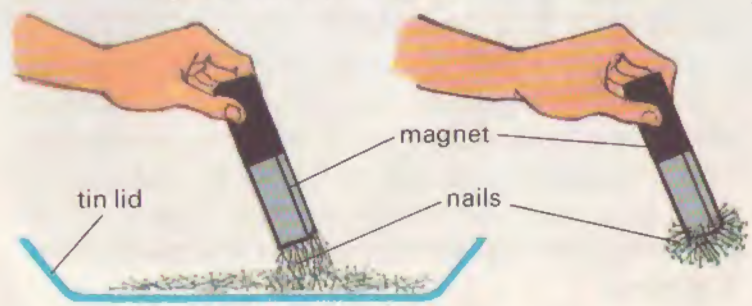
MAGNETS

Lodestone is a form of iron ore. It has two interesting properties:

1. Lodestone attracts small pieces of iron.
2. When lodestone is hung freely or floated on wood in water it points in a north-south direction.

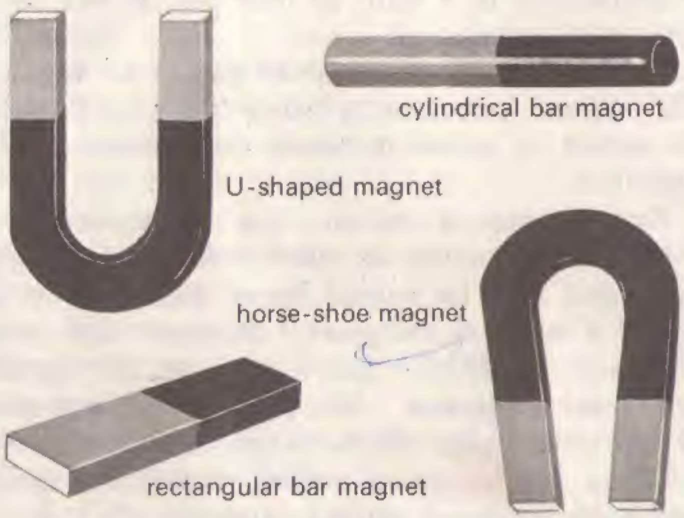
Any substance which, like lodestone, has these two properties is called a **magnet**. Since lodestone can be mined from the earth it is called a **natural magnet**. Magnets can also be made by Man. Such magnets are called **artificial magnets**. Many magnets are made of iron and steel. Some magnets are made of mixtures of aluminium, nickel, cobalt and iron, and such magnets are very strong.

Magnets attract magnetic substances.



SHAPES OF MAGNETS

Magnets are of many shapes. Some are cylindrical rods and some are rectangular bars. They are called 'bar magnets'. Some are U-shaped. Some are called 'horse-shoe magnets' because they look like horse-shoes.



Magnets of different shapes

MATERIALS A MAGNET WILL ATTRACT

A substance which is attracted by a magnet is called a **magnetic** substance. A substance which is not attracted by a magnet is called a **non-magnetic** substance. A magnetic substance can be made into a magnet. A non-magnetic substance cannot be made into a magnet.

Things to Do

Use a magnet to find out whether the following substances are magnetic or non-magnetic.

(1)	ruler	(2)	pencil
(3)	comb	(4)	tin
(5)	glass	(6)	nail
(7)	screw driver	(8)	coin
(9)	scissors	(10)	matchbox
(11)	chalk	(12)	cork
(13)	thumb tack	(14)	eraser
(15)	clothes peg		

Testing substances with a magnet

THE STRONGEST PARTS OF A MAGNET

A magnet has an attractive force on magnetic materials. Is the attractive force the same all over a magnet?

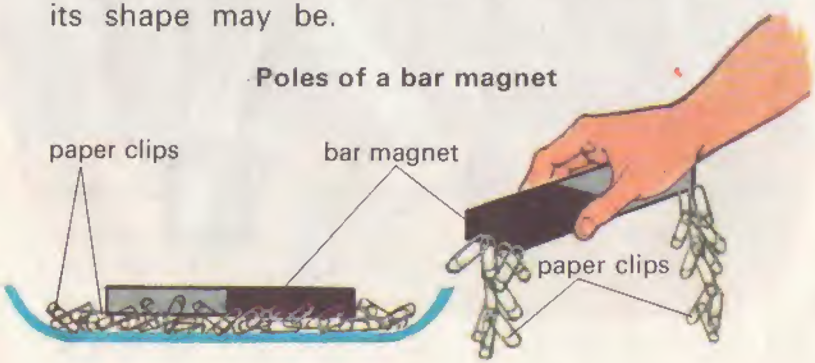
Things to Do

Place a bar magnet in a container with paper clips in it. Pick up the magnet. Do any clips cling to the magnet? Where do most of the clips cling?

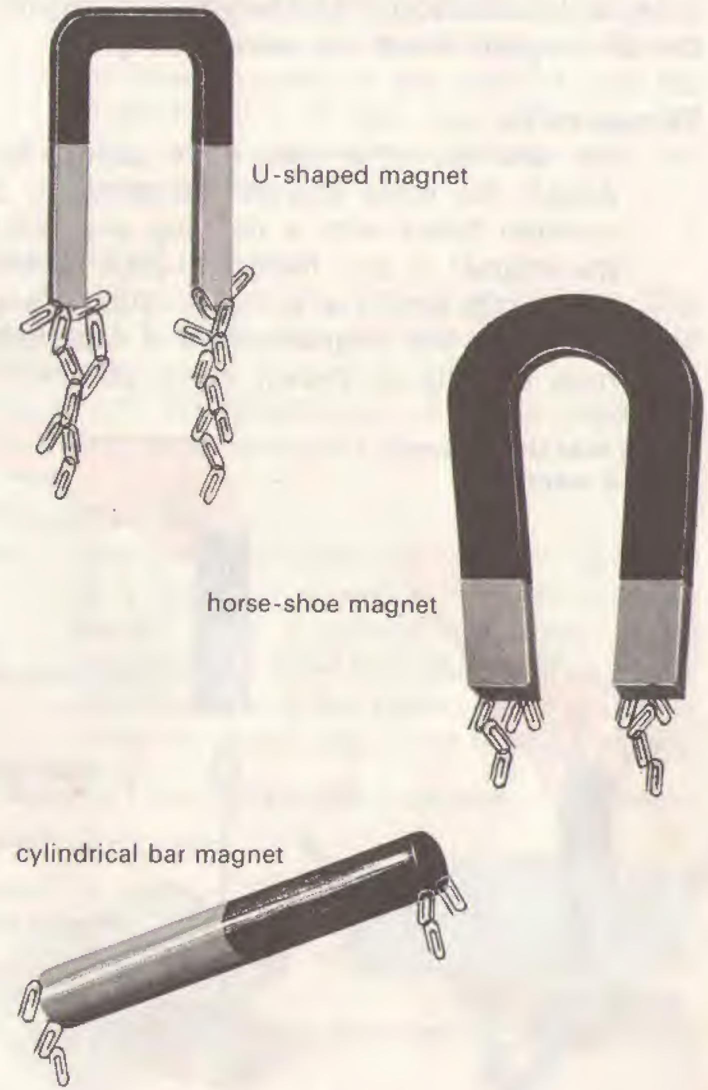
The experiment shows that the ends of the magnet have greater **magnetic force** than the middle portion of the magnet. Repeat the experiment with U-shaped, horse-shoe and cylindrical magnets. Do the ends of the magnets have greater magnetic force than the other parts?

The ends of a magnet are called the **magnetic poles** of the magnet. There is a magnetic pole at each end of a magnet. There always are magnetic poles on a magnet, no matter what its shape may be.

Poles of a bar magnet



Poles of other magnets



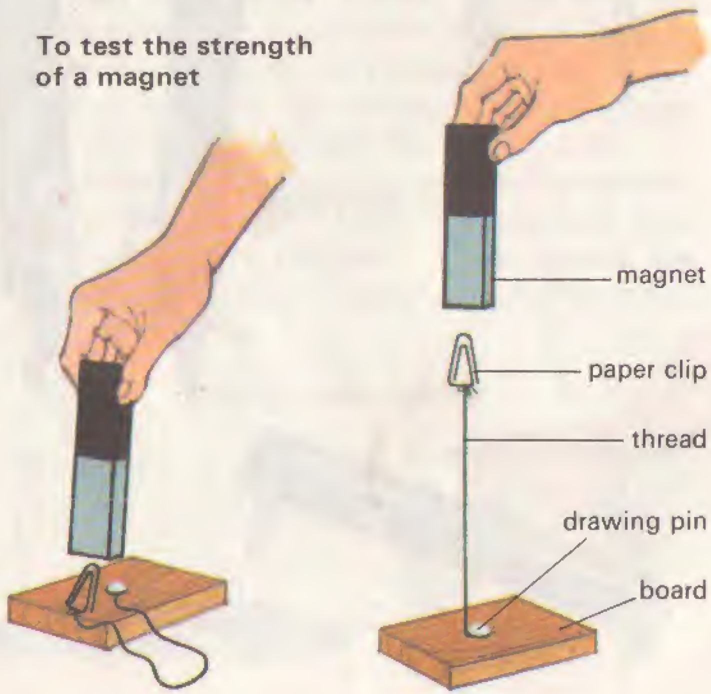
THE STRENGTH OF A MAGNET

Let us find out about the strength of a magnet. Do all magnets have the same strength?

Things to Do

Tie one end of a string to a paper clip. Attach the other end of the string to a wooden board with a drawing pin. Hold the magnet in one hand and pick up the paper clip until the string is taut. Keep on raising the magnet until it is separated from the clip as shown in the picture.

To test the strength of a magnet



Keep on raising the magnet until the paper clip just begins to fall to the wooden board. Measure the distance between the lowest point in the magnet and the highest point of the clip. Repeat this with other magnets. Which was the strongest magnet?

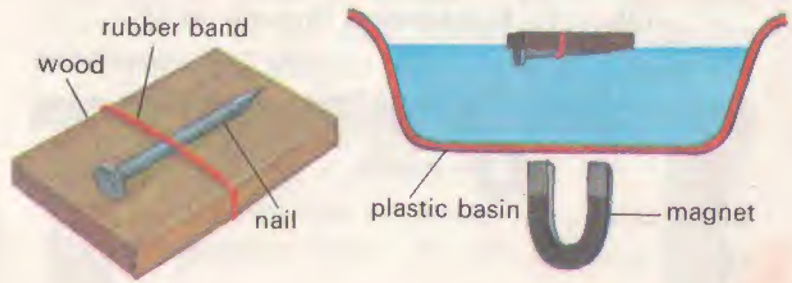
MAGNETIC FORCE

A magnet has an attractive force. This magnetic force is able to pass through certain substances.
What are the substances that the magnetic force can pass through?

Things to Do

(i) Use a rubber band to hold an iron nail to a piece of wood which will float on water. Take a plastic basin and fill it with water. Now float the wood with the attached nail, in the basin. Hold a magnet under the basin and move it about slowly.

Magnetic force can pass through plastic and water.



You will find that the wood will move in the same direction as the magnet. This is because the magnetic force is able to pass through the plastic basin and water, to attract the iron nail.

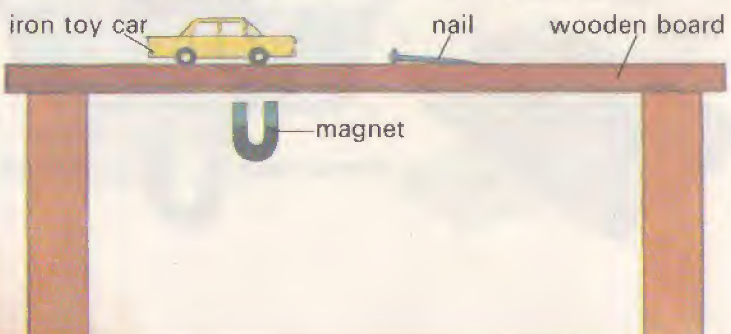
Hold the magnet further away from the bottom of the basin. Does the piece of floating wood move as readily as it did before?

(ii) Take an iron nail, or a toy car made of iron, and place it on a wooden board. Hold a magnet about two centimetres below the wooden board and move it about slowly.

You will find that the nail, or the toy car, will move in the same direction as the magnet. This is because the magnetic force is able to pass through the piece of wood.

Now use different sheets of materials like glass, rubber and iron to see if the magnetic force is able to pass through them.

Magnetic force passes through wood.

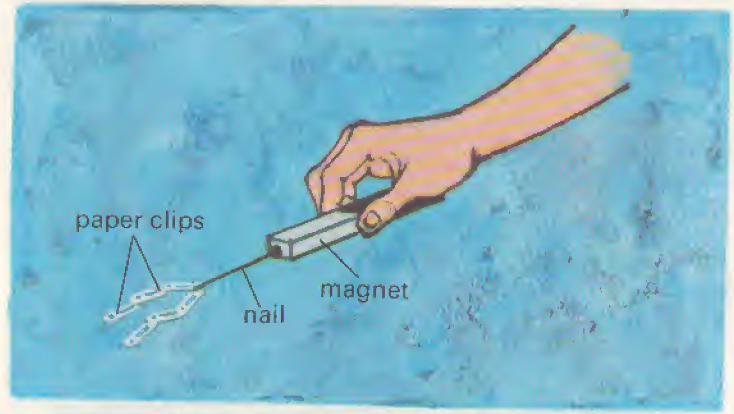


HOW TO MAKE MAGNETS

We can make our own magnets. Let us find out how we can do this.

Things to Do

(i) Take a magnet, a large iron nail and some paper clips. Touch the paper clips with the iron nail. Does the iron nail attract the paper clips?

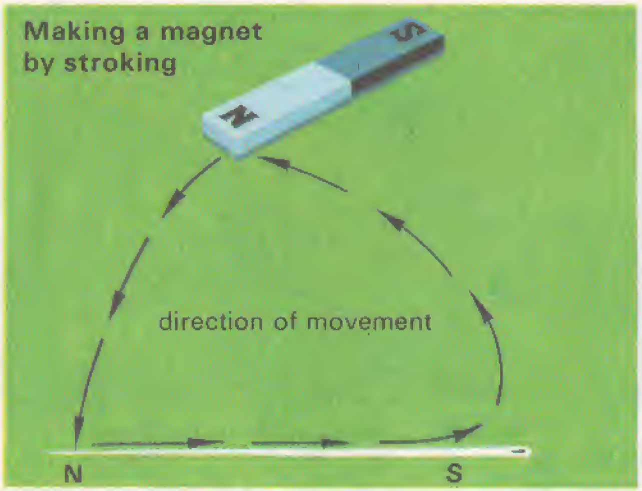


Making a magnet by induction

Now place the magnet, the nail and the paper clips in a line. Move the clips closer to the nail. What happens to the clips? Take the magnet away. Does the nail still attract the clips? Does the nail still attract the paper clips a little while later?

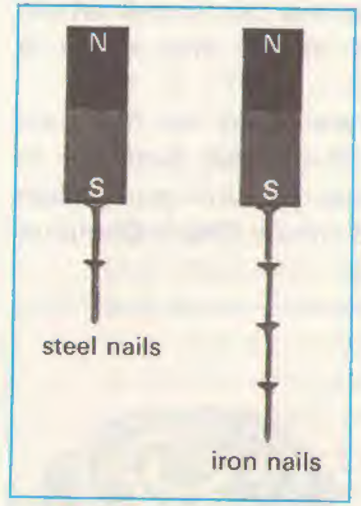
(ii) Take a magnet, a steel knitting needle and some paper clips. Put the knitting needle

on a table and then stroke it with a magnet. Stroke the knitting needle in one direction, from one end of the needle to the other, using the same pole of the magnet all the time. Do this about 30 times. Pick up some paper clips with it. Your knitting needle has now become a magnet. Does the knitting needle still attract the paper clips a little while later?

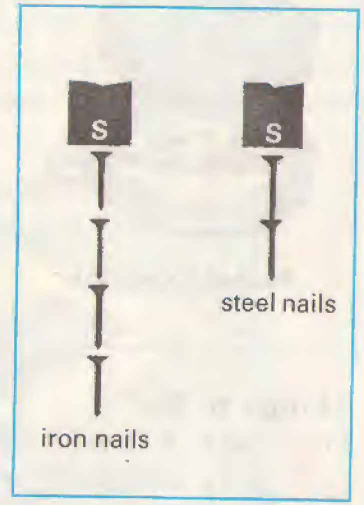


TYPES OF MAGNETS

There are two kinds of magnets: **temporary magnets** and **permanent magnets**. Temporary magnets are usually made of iron and are able to keep their magnetism for a short time only. Permanent magnets are usually made of steel and are able to keep their magnetism for a long time.



Iron is more easily magnetised than steel.



Iron loses its magnetism more quickly than steel.

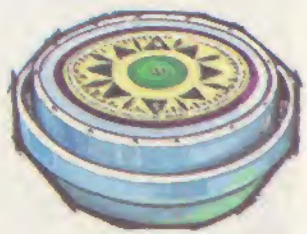
MAGNETIC COMPASSES

In a magnetic compass the magnetic needle is supported in such a way that it can rotate freely. When the compass is placed at rest, the needle will come to rest in a north-south direction. The two ends of the needle are

marked differently so that we can know which is the North Pole of the needle and which is the South Pole.

Magnetic compasses are used by travellers and **navigators** to tell them the direction in which they are travelling. Two compasses which are commonly used are the Ship's Compass and the Pocket Compass.

Pocket Compass



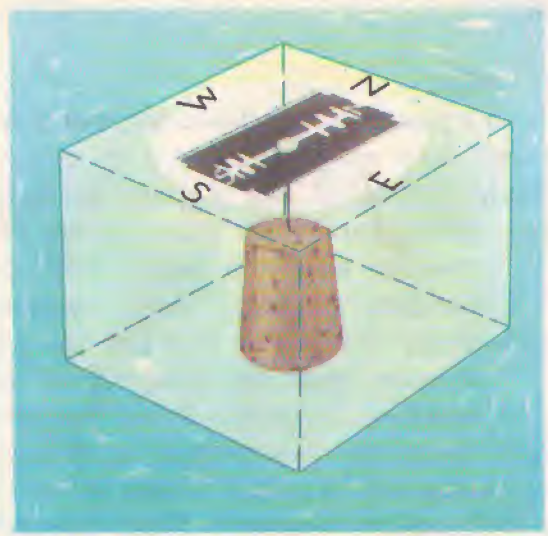
Ship's Compass

Things to Do

(i) Take a steel razor blade and magnetize it by stroking it with a magnet. Now you have a 'razor blade magnet'. Mark the North Pole of the razor blade and fix it to a piece of cork. Float the cork in water. See that there are no magnets or magnetic substances around. When the cork stops moving, the razor blade will point in a north-south direction.

(ii) Magnetize a razor blade with a magnet as you did earlier. Mark the North Pole on it. Push a press stud into the centre of the razor blade and fix it tightly with some paper. Glue the razor blade onto a round piece of cardboard and mark the North Pole on the card. Now suspend the cardboard with the razor blade on a pin stuck through a piece of cork so that it is able to move freely. You have made a simple compass. Keep your compass in a cardboard box so that it will not be blown about by the wind. Use the compass to find the direction in which your class is facing.

A 'razor blade magnet'



MAGNETIC POLES

A magnet has two magnetic poles. The two ends of the magnet usually have opposite magnetic poles. In some cases the two ends of the magnet will have the same magnetic poles because the magnets were made in that way.

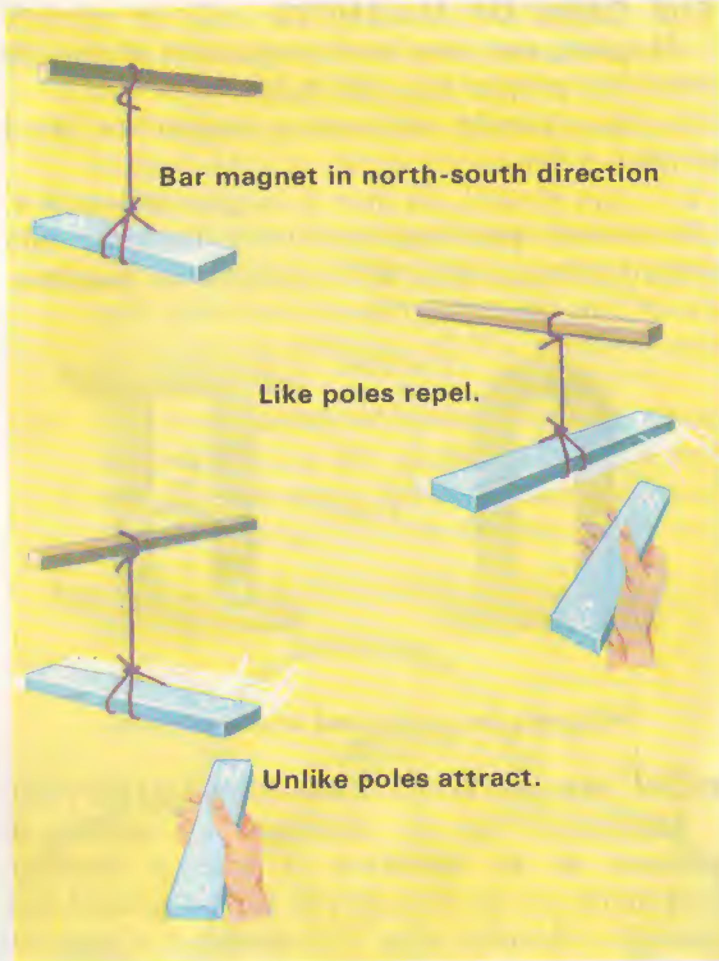
The North Pole of a magnet will attract or pull the South Pole of another magnet. The South Pole of a magnet will attract the North Pole of another magnet. Therefore unlike or different poles attract.

The North Pole of a magnet will repel or push the North Pole of another magnet. The South Pole of a magnet will also repel the South Pole of another magnet. Therefore like poles repel.

Things to Do

(i) Take a piece of thread and two bar magnets. Hang one magnet so that it can rotate freely. When it has stopped rotating:

- (*a*) Bring the North Pole of the second magnet near the North Pole of the hanging magnet. What happens?
- (*b*) Bring the North Pole of the second magnet near the South Pole of the hanging magnet. What happens?
- (*c*) Bring the South Pole of the second magnet near the North Pole of the hanging magnet. What happens?

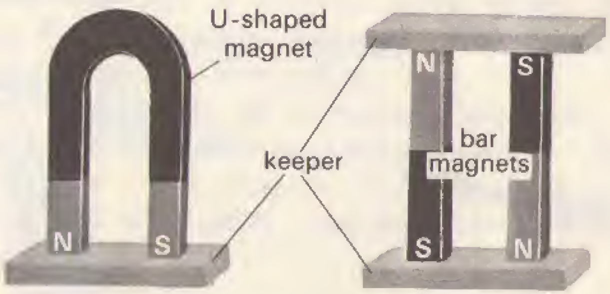


(ii) Magnetize a piece of hacksaw blade by stroking it with a magnet. Break the blade at the centre. Do the ends of each broken piece have opposite magnetic poles?

THE CARE OF MAGNETS

Magnets can lose their magnetism if you do not take proper care of them.

1. You should not heat a magnet or place it near a fire.
2. You should not drop a magnet or knock it.
3. When you are not using magnets you should protect them with **magnetic keepers**.



Magnets are protected with 'keepers'.

HOW MAGNETISM CAN BE DESTROYED

Magnetism can be destroyed by heating a magnet, or by knocking it with a hammer repeatedly, or by dropping it to the ground repeatedly. Another way of destroying a magnet is by using an electrical method.

The strength of a magnet will be known by the number of paper clips it can pick up. When the magnetism in a magnet is completely destroyed, it will not pick up any paper clips.

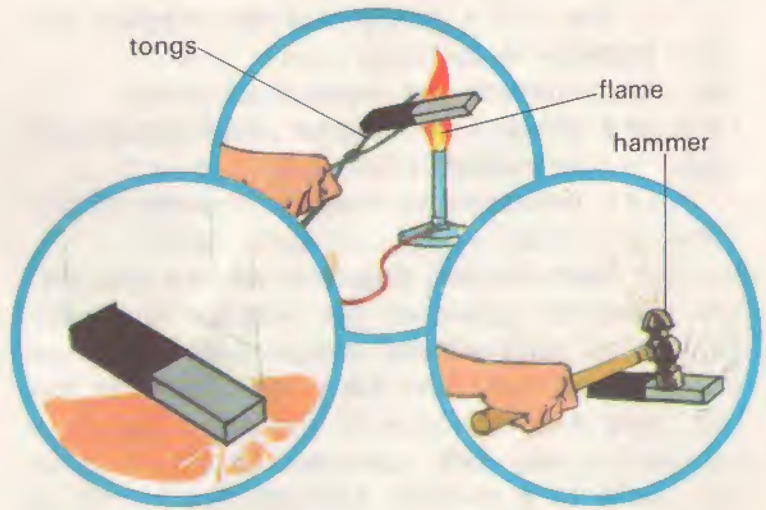
Things to Do

(i) Test the strength of your magnet. Heat the magnet very gently for a short while and test its strength. Heat the magnet strongly for a short while and test its strength.

(ii) Take another magnet and test its strength. Hit the magnet with a hammer 10 times and test its strength. Repeat this twice and test the strength of the magnet each time.

(iii) Test the strength of another magnet. Drop the magnet to the ground 10 times and test its strength. Repeat this twice and test the strength of the magnet each time.

Magnetism can be destroyed in different ways.



ELECTRICITY AND MAGNETS

Magnets can also be made by using an electrical method. This is the method by which magnets are made in industry. Magnets made in this way are called **electromagnets**.

Things to Do

(i) Wind a copper wire around a steel bar. The wire must be wound so that it is not criss-crossed. Make about 30 turns around the bar.

Connect the two ends of the wire to the poles of the dry cells so that an electric current can flow through the wire.

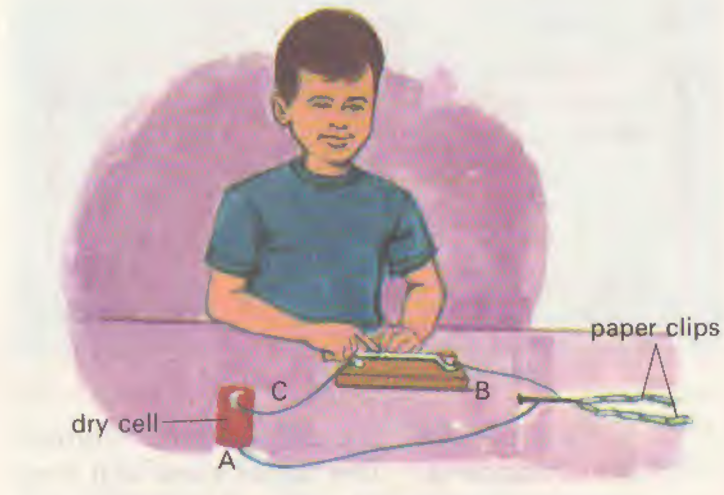
After a while disconnect the wire from the dry cells. Test the steel bar with a compass. Is it a magnet now?

See if the strength of the magnet will increase if you

(*a*) increase the number of cells,
(*b*) increase the time for which the current is passed, and
(*c*) increase the number of turns of the wire.

Reverse the direction of the current. Are the poles of the magnet reversed?

(ii) Wind an insulated copper wire round an iron nail at least 10 times. Connect the end A of the wire to the **negative pole** of a dry cell. Join end B of the same wire to a switch. Connect the switch to

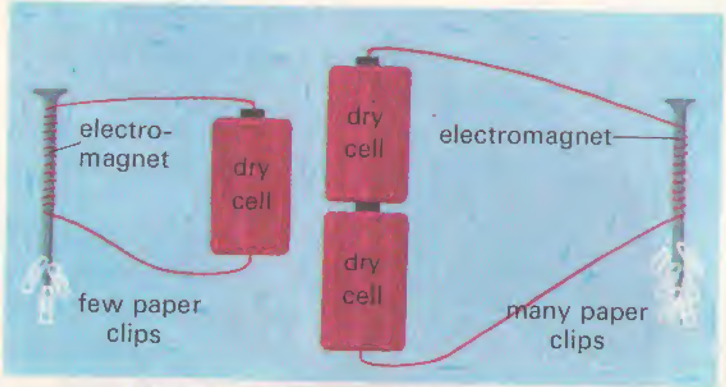


An electromagnet

the **positive pole** of the dry cell with another wire C.

Place a few paper clips on the table. Without closing the circuit, touch the paper clips with the nail. What happens? The iron nail will not attract the paper clips as it is not a magnet.

Now close the circuit so that an electric current flows through the coil of wire around the nail. Now hold the nail near the paper clips. What happens? Some paper clips will be attracted to the magnet. This shows that the nail is now a magnet. How many clips are picked up now?



Which electromagnet is stronger?

Now switch off the electric current. What happens? The paper clips will drop away from the iron nail. This shows that the nail is no longer a magnet.

Repeat the experiment but increase the number of turns of wire around the nail. Is the strength of the electromagnet increased? Repeat the experiment but use two cells this time. Is the strength of the electromagnet increased?

The strength of the electromagnet increases with the number of turns of the wire and the number of cells used.

USES OF MAGNETS

Magnets are used in the making of the Pocket Compass and the Ship's Compass. Magnets are also used in electrical instruments, motors and dynamos.

Electromagnets have a number of uses:

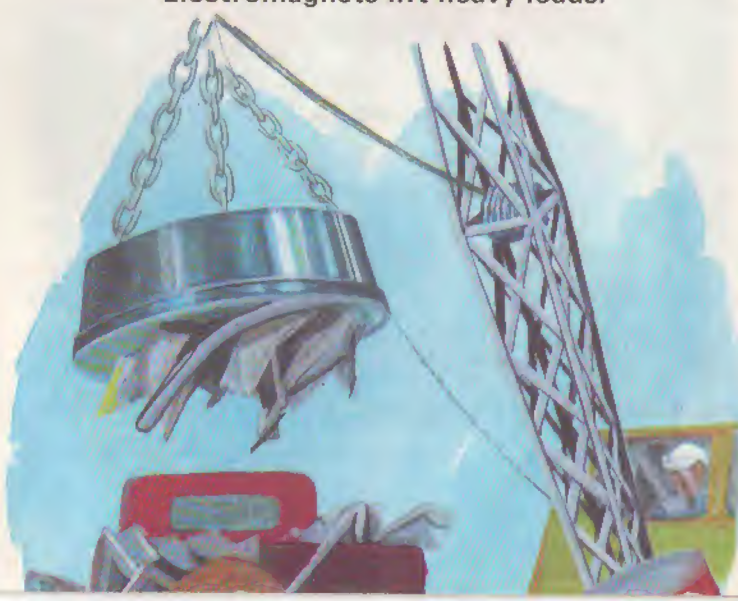
(i) Electromagnets attached to large cranes attract and move heavy loads of scrap iron and iron sheets. The electromagnet only lifts the load when a current is flowing through it. Once the current is switched off, it ceases to be a magnet, and so drops the load.

(ii) Electromagnets are used to remove 'foreign bodies' such as iron nails and other magnetic substances from a patient's body.

(iii) Electromagnetic separators are used for separating magnetic substances (iron, steel, nickel and cobalt) from non-magnetic substances (tin, brass and copper).

(iv) Electromagnets are also used in electric bells, telephones and transformers.

Electromagnets lift heavy loads.



THE ELECTRIC BUZZER

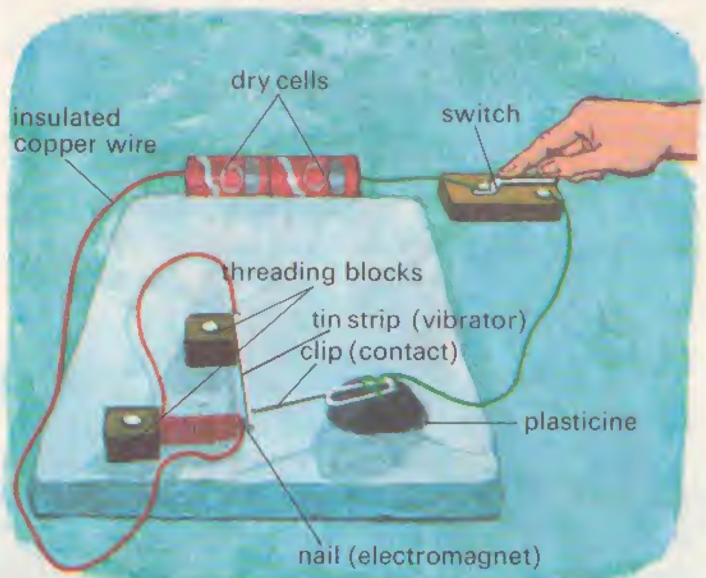
The **electric buzzer** is made up of three main parts:

(*a*) the electromagnet,
(*b*) the **vibrator** and
(*c*) the **contact**.

The coil, the cell, the contact and the vibrator form an **electric circuit**. Wherever connections are made in the electric circuit, the metals forming the connections should be bare and clean.

Here is the list of things you require to make a buzzer: a 3-cm nail, a switch, insulated

The electric buzzer



copper wire, a new cell or two old cells, a strip of tin 1 cm wide and 4 cm long, 1 paper clip, 2 threading blocks, a little plasticine and some sticky tape.

To make the buzzer, wind a metre of insulated copper wire on the 3-cm nail leaving about 10 cm of wire free at either end. Use a drawing pin to fix one end of the tin strip and a bare end of the wire to a threading block. Make sure that the tin strip, where it presses on the wire, is clean. Fix the threading block to the board by putting a nail through the hole in the block. Fix the electromagnet in such a way that the head of the nail almost touches the free end of the tin strip. Fix the other bare end of the wire to a cell with a piece of adhesive tape. Fix a second piece of wire to the other terminal of the cell. Connect the other end of this wire to one terminal of a switch. Use a third wire to connect the other terminal of the switch to a pointed paper clip anchored in plasticine. Adjust the point of the paper clip so that it just touches the tin strip. Press the switch. Does the buzzer work?

The buzzer may not work the first time you press the switch. If it does not work, decrease the distance between the vibrator and the electromagnet until the buzzer works. Then adjust the pressure of the clip on the vibrator until you get the loudest buzz.

MAGNETIC FIELD

A magnet exerts a force on magnetic substances placed near it. The force is greatest at the poles of the magnet. The force is in the magnet itself. The force is also felt outside the magnet. The region around the magnet in which the magnetic force can be felt by a magnetic substance is called the **magnetic field** of the magnet. You cannot see a magnetic field but you can see what the force in a magnetic field can do.

Things to Do

(i) Sprinkle some iron filings on a white cardboard. Move a bar magnet just below the board. Do the iron filings move with the magnet? If they do, the iron filings are in the field of the bar magnet.

(ii) Move the magnet further away from the board. Do the iron filings move as the magnet is moved about? If they do not, the iron filings are not in the field of the bar magnet.

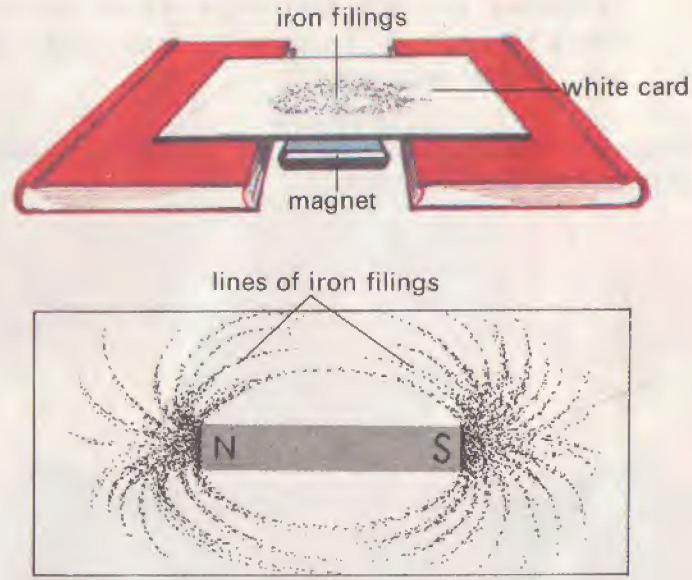
(iii) Place a bar magnet on the table between two exercise books. Cover the magnet with a white cardboard. Sprinkle iron filings gently on the cardboard over a wide area. Tap the board gently. Are the iron filings arranged in any pattern?

The pattern of filings seems to be made of lines. Most of the lines of filings are curved.

The curved lines of filings run from one pole of the magnet to the other. The lines of filings show how the magnetic field of the bar magnet acts. The lines of filings are the **lines of magnetic force**. The lines of force are closest together at the poles of the magnet. There are no lines of force at the centre of the magnet. This shows that the magnetic field is strongest at the poles of the magnet and weakest at the centre of the magnet.

Now let us examine the lines of magnetic force which are formed when two magnets are placed close together.

Magnetic field of a bar magnet

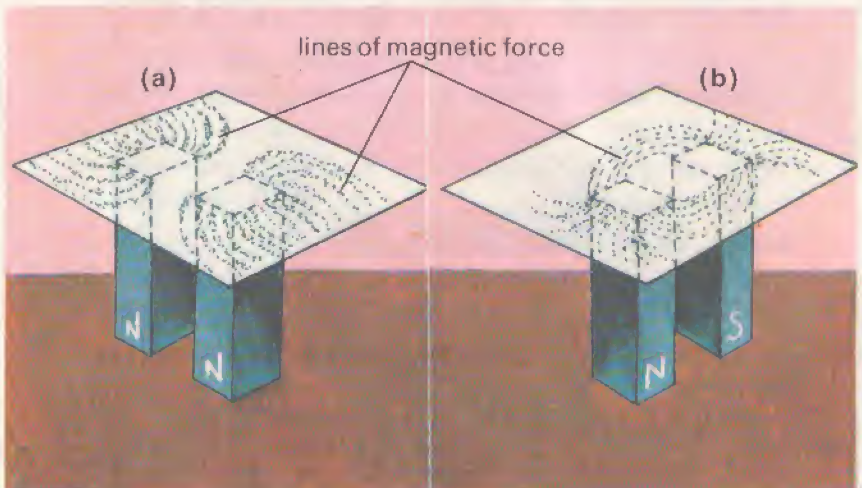


Things to Do

(i) Take two magnets and place them on their ends so that the North Pole of one is about five centimetres away from the North Pole of the other. Place a cardboard above the two magnets and sprinkle iron filings on it. Gently tap the paper. Observe the magnetic field traced by the iron filings.

(ii) Take two magnets and place them on their ends so the North Pole of one is about five centimetres away from the South Pole of the other. Place a cardboard above the two magnets and sprinkle iron filings on it. Gently tap the paper. Observe the magnetic field traced by the iron filings. Is it similar to that produced by a bar magnet?

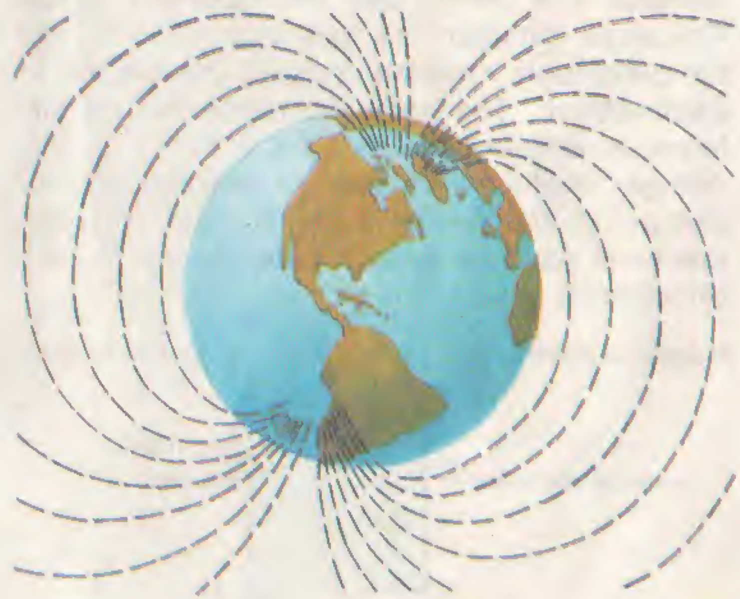
Magnetic fields produced (a) by two like poles, (b) by two unlike poles.



EARTH'S MAGNETISM

When a bar magnet is hung freely it comes to rest in a north-south direction. Another bar magnet hung in the same way, some distance away, will also come to rest in the same direction as the first magnet. The reason the bar magnets come to rest in a north-south direction is because of the Earth's magnetism. There is a very large magnetic field all around the Earth. The magnetic field seems to be produced by a huge magnet in the Earth, with its South Pole pointing towards the north and its North Pole pointing towards the south. The force in

Magnetic field of the Earth



the Earth's magnetic field acts upon each magnetic needle or bar magnet which is hung freely so that they point in the north-south direction. Scientists are still not certain how the Earth got its magnetism.

The magnetic poles of the Earth are not at the same positions as the geographic poles (i.e. the North Pole and the South Pole). They are a short distance away from each other. Any place on Earth would have a **geographic meridian** and a **magnetic meridian**. The geographic meridian is the flat surface that contains the place and the geographic poles. The magnetic meridian is the flat surface that contains the place and the magnetic poles. The angle between the magnetic meridian and the geographic meridian is called the **magnetic declination**. The magnetic declination is different at different places on the Earth. It also changes slightly from year to year because of changes in the Earth's magnetic field. Navigators must consider magnetic declination in their calculations.

Magnetic declination